Claims

1. A heat exchanger for cooling a fiber moving continuously through the heat exchanger, comprising:

a fiber receiving conduit including a fiber inlet to receive the fiber, a fiber outlet through which the fiber exits the fiber receiving conduit, and an internal passage disposed between the fiber inlet and fiber outlet to cool the fiber moving through the fiber receiving conduit;

wherein the internal passage includes at least two adjustable seals with variable orifices that partition the internal passage into a first chamber, a second chamber, and a primary cooling chamber, the first chamber includes an inlet port to receive a first fluid medium, and the second chamber is disposed between the first chamber and the primary cooling chamber and includes an inlet port to receive a second fluid medium.

2. The heat exchanger of claim 1, further comprising:

an outer conduit disposed around the fiber receiving conduit and defining a chamber between the outer surface of the fiber receiving conduit and the inner surface of the outer conduit, the outer conduit including an inlet port and an outlet port to facilitate a flow of a third fluid medium through the chamber.

3. The heat exchanger of claim 1, further comprising:

at least two adjustable seals to further partition the internal passage into a third chamber and a fourth chamber, wherein the fourth chamber includes an inlet port to receive the first fluid medium, and the third chamber is disposed between the fourth chamber and the primary cooling chamber and includes an inlet port to receive the second fluid medium.

4. The heat exchanger of claim 3, wherein the first and second chambers are disposed proximate the fiber outlet, and the third and fourth chambers are disposed proximate the fiber inlet.

5. The heat exchanger of claim 3, wherein the third chamber includes an outlet port that is in fluid communication with a recycle inlet port of the second chamber via a recycle line to facilitate recycling of the second fluid medium from the third chamber into the second chamber.

6. The heat exchanger of claim 1, wherein at least one of the first, second and primary cooling chambers includes a sample extraction port securable to a gas analyzer to facilitate extraction of fluid samples from the chamber for measuring a concentration of one or more gases in the samples by the gas analyzer.

7. The heat exchanger of claim 1, wherein the first fluid medium is the same as the second fluid medium.

8. The heat exchanger of claim 1, wherein the first fluid medium is different than the second fluid medium.

9. A fiber coolant system comprising:

a heat exchanger comprising a fiber receiving conduit including a fiber inlet to receive the fiber, a fiber outlet through which the fiber exits the fiber receiving conduit, and an internal passage disposed between the fiber inlet and fiber outlet to cool the fiber moving through the fiber receiving conduit, the internal passage including at least one adjustable seal with a variable orifice to partition the internal passage into at least one chamber; and

a controller in communication with the adjustable seal to effect opening and closing of the variable orifice to a selected dimension during system operation.

10. The fiber coolant system of claim 9, further comprising:

an outer conduit disposed around the fiber receiving conduit and defining a chamber between the outer surface of the fiber receiving conduit and the inner surface of the outer conduit, the outer conduit including an inlet port and an outlet port to facilitate a flow of a fluid medium through the chamber.

11. The fiber coolant system of claim 9, wherein the internal passage includes first and second adjustable seals that partition the internal passage into a first chamber, a second chamber, and a primary cooling chamber, the first chamber includes an inlet port to receive a first fluid medium, the second chamber is disposed between the first chamber and the primary cooling chamber and includes an inlet port to receive a second fluid medium, and the controller is in communication with the first and second adjustable seals to independently effect opening and closing of the variable orifices of the first and second adjustable seals to selected dimensions during system operation.

12. The fiber coolant system of claim 11, wherein the internal passage further includes third and fourth adjustable seals to further partition the internal passage into a third chamber and a fourth chamber, wherein the fourth chamber includes an inlet port to receive the first fluid medium, and the third chamber is disposed between the fourth chamber and the primary cooling chamber and includes an inlet port to receive the second fluid medium;

wherein the controller is in communication with the third and fourth adjustable seals to independently effect opening and closing of the variable orifices of the third and fourth adjustable seals to selected dimensions during system operation.

13. The fiber coolant system of claim 12, wherein the third chamber includes an outlet port that is in fluid communication with a recycle inlet port of the second chamber via a recycle line, and the controller is configured to communicate with a pump disposed along the recycle line to facilitate recycling of the second fluid medium from the third chamber into the second chamber at a selected flow rate.

14. The fiber coolant system of claim 11, further comprising a gas analyzer in fluid communication with an extraction port disposed on at least one of the first, second and primary cooling chambers, and the controller communicates with the gas analyzer to facilitate extraction of fluid samples from

at least one of the first, second and primary cooling chambers for measuring a concentration of one or more gases in the samples by the gas analyzer.

15. The fiber coolant system of claim 14, wherein the gas analyzer measures the concentration of at least one of oxygen, nitrogen and carbon dioxide in the extracted fluid samples.

16. The fiber coolant system of claim 14, wherein the controller effects opening or closing of the seal orifice of at least one of the first and second adjustable seals when the measured concentration of one or more gases in an extracted fluid sample exceeds a threshold value.

17. The fiber coolant system of claim 14, wherein the controller is configured to independently effect manipulation of a first valve that controls the flow of the first fluid medium to the first chamber and a second valve that controls the flow of the second fluid to the second chamber so as to independently control the flow rates the first fluid medium to the first chamber and the second fluid medium to the second chamber.

18. The fiber coolant system of claim 17, wherein the controller effects manipulation of at least one of the first and second valves when the measured concentration of one or more gases in an extracted fluid sample exceeds a threshold value.

19. The fiber coolant system of claim 11, wherein the first fluid medium is the same as the second fluid medium.

20. The fiber coolant system of claim 11, wherein the first fluid medium is different than the second fluid medium.

21. The fiber coolant system of claim 11, further comprising:

a first fluid medium supply source to deliver the first fluid medium to the inlet port of the first chamber; and

a second fluid medium supply source to deliver the second fluid medium to the inlet port of the second chamber.

22. The fiber coolant system of claim 21, wherein each of the first and second fluid mediums comprises at least one of helium, neon, argon, krypton, xenon, hydrogen, nitrogen, and carbon dioxide.

23. The fiber coolant system of claim 22, wherein the second fluid medium further comprises at least one of a silane, a phosphine, fluorine, chlorine, and gaseous organometallic compounds.

24. The fiber coolant system of claim 9, further comprising:

a plurality of heat exchangers aligned with each other to facilitate travel of the fiber through the heat exchangers and independent cooling of the fiber within each heat exchanger.

25. The fiber coolant system of claim 24, further comprising a plurality of fluid medium supply sources connected to the heat exchangers to supply fluid medium to at least a portion of the internal passage of each heat exchanger, wherein at least two fluid medium supply sources supply a different fluid medium to at least two heat exchangers.

26. The fiber coolant system of claim 24, further comprising:

an outer conduit disposed around the fiber receiving conduit of each heat exchanger and defining a chamber between the outer surface of the fiber receiving conduit and the inner surface of the outer conduit, the outer conduit including an inlet port and an outlet port to facilitate a flow of a fluid medium through the chamber; and

a plurality of fluid medium supply sources to deliver fluid medium to the inlet ports of the outer conduits of the heat exchangers;

wherein at least two fluid medium supply sources deliver fluid medium at a different temperature to the inlet port of the outer conduits of at least two heat exchangers.

27. A fiber coolant system comprising:

a heat exchanger comprising a fiber receiving conduit including a fiber inlet to receive the fiber, a fiber outlet through which the fiber exits the fiber receiving conduit, and an internal passage disposed between the fiber inlet and fiber outlet to cool the fiber moving through the fiber receiving conduit, the internal passage including a plurality of chambers with at least one fluid medium flowing within at least a portion of the internal passage and at least one adjustable seal being positioned within the internal passage to form a partition between two adjacent chambers;

a gas analyzer in fluid communication with at least one chamber of the internal passage to extract a fluid sample from the at least one chamber and measure a concentration of at least one gas in the extracted fluid sample; and

a controller in communication with the gas analyzer and the at least one adjustable seal to effect at least one of an adjustment of a dimension of a variable orifice of the at least one adjustable seal and the flow rate of fluid medium within the internal passage when the measured concentration of the at least one gas in the extracted fluid sample exceeds a threshold value.

28. A method of cooling a fiber in a coolant system, the coolant system including a heat exchanger with a fiber receiving conduit including a fiber inlet, a fiber outlet, and an internal passage disposed between the fiber inlet and fiber outlet, the internal passage including at least one adjustable seal with a variable orifice, and a controller in communication with the adjustable seal, the method comprising:

passing a fiber through the internal passage between the fiber inlet and the fiber outlet; and

manipulating the at least one adjustable seal, via the controller, to selectively adjust a dimension of the seal orifice.

29. The method of claim 28, wherein the heat exchanger further includes an outer conduit disposed around the fiber receiving conduit and

defining a chamber between the outer surface of the fiber receiving conduit and the inner surface of the outer conduit, and the method further comprises:

flowing a fluid medium through the chamber between an inlet port and an outlet port of the outer conduit.

30. The method of claim 29, wherein the fluid medium comprises at least one of water, one or more hydrocarbons, a substantially pure gas and a substantially pure liquid.

31. The method of claim 30, wherein the fiber is passed through the internal passage of a plurality of heat exchangers, and the temperature of fluid medium flowing through the chamber of at least one heat exchanger is different than the temperature of fluid medium flowing through the chamber of at least one other heat exchanger.

32. The method of claim 28, wherein the internal passage includes first and second adjustable seals that partition the internal passage into a first chamber, a second chamber, and a primary cooling chamber, the first chamber includes an inlet port, the second chamber is disposed between the first chamber and the primary cooling chamber and includes an inlet port, and the controller is in communication with the first and second adjustable seals, the method further comprising:

flowing a first fluid medium into the first chamber via the inlet port of the first chamber;

flowing a second fluid medium into the second chamber via the inlet port of the second chamber;

wherein the first and second adjustable seals are independently manipulated, via the controller, to selectively adjust a dimension of the orifice of each adjustable seal.

33. The method of claim 32, wherein the first fluid medium is the same as the second fluid medium.

34. The method of claim 32, wherein the first fluid medium is different than the second fluid medium.

35. The method of claim 32, wherein each of the first and second fluid mediums comprises at least one of helium, neon, argon, krypton, xenon, hydrogen, nitrogen, and carbon dioxide.

36. The method of claim 35, wherein the second fluid medium further comprises at least one of a silane, a phosphine, fluorine, chlorine, and gaseous organometallic compounds.

37. The method of claim 32, wherein the second fluid medium comprises one of helium, hydrogen and a mixture of hydrogen and helium.

38. The method of claim 32, wherein the first fluid medium comprises at least one of argon and carbon dioxide.

39. The method of claim 32, wherein the fiber is passed through the internal passage of a plurality of heat exchangers, and the second fluid medium that is flowed into the second chamber of at least one heat exchanger is different than the second fluid medium that flows into the second chamber of at least one other heat exchanger.

40. The method of claim 32, wherein the internal passage further includes third and fourth adjustable seals to further partition the internal passage into a third chamber and a fourth chamber, wherein the fourth chamber includes an inlet port, and the third chamber is disposed between the fourth chamber and the primary cooling chamber and includes an inlet port, and the controller is in communication with the third and fourth adjustable seals, the method further comprising:

flowing the first fluid medium into the fourth chamber via the inlet port of the fourth chamber;

flowing the second fluid medium into the third chamber via the inlet port of the third chamber;

wherein the third and fourth adjustable seals are independently manipulated, via the controller, to selectively adjust a dimension of the orifice of each adjustable seal.

41. The method of claim 40, wherein the third chamber includes an outlet port that is in fluid communication with a recycle inlet port of the second chamber via a recycle line, and the coolant system further includes a pump that is in communication with the controller, and the method further includes:

controlling the pump, via the controller, to recycle the second fluid medium from the third chamber into the second chamber at a selected flow rate.

42. The method of claim 32, wherein the coolant system further comprises a gas analyzer in fluid communication with an extraction port disposed on at least one of the first, second and primary cooling chambers, and the controller is in communication with the gas analyzer, the method further comprising:

extracting a fluid sample from at least one of the first, second and primary cooling chambers; and

measuring a concentration of one or more gases in the extracted fluid sample via the gas analyzer.

43. The method of claim 42, wherein the gas analyzer measures the concentration of at least one of oxygen, nitrogen and carbon dioxide in the extracted fluid sample.

44. The method of claim 42, wherein the controller effects manipulation of at least one of the first and second adjustable seals to adjust the dimension of the orifice associated with the manipulated seal when the measured concentration of one or more gases in an extracted fluid sample exceeds a threshold value.

45. The method of claim 42, further comprising:

automatically manipulating a first valve connected with the inlet port of the first chamber, via the controller, to open or close so as to control the flow rate of the first fluid medium into the first chamber; and

automatically manipulating a second valve connected with the inlet port of the second chamber, via the controller, to open or close so as to control the flow rate of the second fluid medium into the second chamber.

46. The method of claim 45, wherein the controller effects manipulation of at least one of the first and second valves to open or close when the measured concentration of one or more gases in an extracted fluid sample exceeds a threshold value.

47. The method of claim 28, wherein the fiber is an optical fiber.

48. A method of cooling a fiber utilizing a coolant system including a heat exchanger with an internal passage having a plurality of chambers and at least one adjustable seal that forms a partition between two adjacent chambers, a gas analyzer in fluid communication with at least one chamber of the internal passage, and a controller in communication with the gas analyzer and the at least one adjustable seal, the method comprising:

passing a fiber through the internal passage of the heat exchanger;

flowing a fluid medium through at least a portion of the internal passage to contact the fiber passing through the internal passage;

extracting a fluid sample from the at least one chamber via the gas analyzer;

measuring a concentration of at least one gas in the extracted fluid sample via the gas analyzer; and

effecting, via the controller, an adjustment of at least one of a dimension of a variable orifice of the at least one adjustable seal and the flow rate of fluid medium within the internal passage when the measured concentration of the at least one gas in the extracted fluid sample exceeds a threshold value.